Rare-earth Information Center NEWS

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CMR Thin Films

Manganite materials exhibit colossal magnetoresistance, or CMR, which is a dramatic increase in the resistance of the material in the presence of a magnetic field. However, the effect is somewhat variable, and is highly dependent on the conditions of material preparation. A recent review article, "Colossal-magnetoresistive manganite thin films," by W. Prellier, Ph. Lecoeur, and B. *Mercey, J. Phys. Condens. Matter* **13** R915-R944 (2001), explores mixed valence perovskite manganites $(RE_{1-x}A_x)MnO_3$, where RE = rare earth and A = alkaline earth.

There are three primary objectives of the article: to present the results and effects of different deposition techniques, to relate structural and physical properties with an emphasis on the effects of strain, and to present possible applications of manganite thin films in spin electronics. The first objective is met by first presenting deposition and characterization techniques. Pulsed laser deposition is a popular method of preparation. However, the oxygen pressure commonly used in this technique precludes the use of reflection high-energy electron diffraction (RHEED) *in situ* to control the growth of the film. Therefore, the technique is modified by using a more oxidizing gas, like atomic oxygen or ozone, and a differential pumping system. Magneton sputtering is another popular deposition technique. Ion beam sputtering, electron beam/thermal coevaporation, molecular beam epitaxy, and metal-organic chemical vapor deposition have also been used. The deposition conditions, including oxygen pressure, and deposition temperature, among others, play a large role in the properties of the material. Oxygen annealings are also necessary to optimize properties. Structural characterization of the films is necessary, as slight variations in the structure have a large effect on the properties. Characterization of the structure is often best done by high-resolution transmission electron microscopy (HREM). This characterization can show the degree of strain present in the film. Standard physical measurements include resistance versus temperature both in zero field and at applied fields and magnetization measurements. Surface measurements and transport across grain boundaries are sometimes studied, as are irradiation effects and phase separation.

The second objective of the article is presented in a section simply called "Effects of Strain." Two major types of strain are discussed: substrate-induced (in-plane) and thickness dependent (out-of-plane). The substrate has a large influence on the structure of the film, including lattice parameters, microstructure, texture, and orientation. The substrate can also affect the physical properties, low field magnetoresistance, and charge ordering of the material. The thickness of the film also affects the lattice parameters and physical properties.

Finally, the potential uses of these materials, especially in thin-film form, are amazing. The control possible in formation of the films means heterostructures and multilayers can be tailored to specific uses. Deposition conditions can be altered to create metastable phases that are more stable at room temperature. Artificial superlattices can be constructed through careful layering of materials. These multilayered structures can be configured to become magnetic or electronic devices, such as magnetic tunnel junctions, field effect devices, bolometric detectors, and spin-injection devices.

This review, while brief, provides a considerable amount of information in an easy-to-read presentation. The overview of manganite thin films it provides covers several important topics, and provides the reader with some areas that have yet to be explored. The work is supported by 20 figures, which help clarify many of the points made, and 240 references, which should provide plenty of further reading for interested parties.

For more information, W. Prellier can be reached at Laboratoire CRISMAT, CNRS UMR 6508, Boulevard du Maréchal Juin, 14050 Caen Cédex, France; e-mail: prellier@ismra.fr. ▲

CeO_2 provides ultraviolet (UV) protection in medical and TV glass, and it acts as an antibrowning agent in TV glass plates.

In This Issue:

5th ICSTR

The Fifth International Conference on Solvothermal Reactions (ICSTR) will be held July 22-26, 2002, at the Hilton East Brunswick in East Brunswick, New Jersey, USA. This conference was brought to the attention of the RIC by Prof. Richard E. Riman, one of the conference chairpersons, as solvothermal reactions are being used to make rare-earth materials, and he thought some of our readers might be interested in attending the conference. They are chemical reactions performed in aqueous and non-aqueous liquids at elevated temperature and pressure. They are a novel low temperature means (soft chemistry approach) for synthesis and processing of materials and industrial chemicals.

The objective of the conference is to address the key issues associated with the science and technology of solvothermal reactions and to encourage commercialization for short- and long-term applications. Worldwide initiatives in areas such as soft solution processing, industrial ecology, advanced materials, and nanotechnology make the conference especially relevant at this point in time. Suggested topics include materials, synthesis and processing, fundamentals, and properties and applications. Subtopics under materials include polymer synthesis; organic synthesis; polycrystalline materials; thin films, layers, and coatings; ceramic oxides and nanoxides; clusters and cluster assembled materials; nanomaterials; and single crystals. Synthesis and processing includes solvothermal, lyothermal, hydrothermal, supercritical, microwave, sonochemical, electrodeposition, biomimetic process, hydrothermal consolidation, hydrometallurgy, extraction and separation, and crystallization. Fundamentals include thermodynamic properties; thermodynamic modeling; phase diagrams; kinetics modeling; dissolution; nucleation, growth, and aging; corrosion; surface chemistry; colloid science; reaction engineering; geochemistry; and *ex-situ* and *in situ* reaction monitoring. Properties and applications can include optical, electrical, magnetic, and mechanical properties, surface properties and catalysis, microstructure property relationships, thermal properties, energy applications, biomedical applications, environmental remediation, nanotechnology, and nanopharmaceuticals.

The normal abstract deadline is March 15, 2002, but Prof. Riman is willing to extend that deadline to early April for the rare-earth community. According to Prof. Riman, "This is a great meeting for those interested in solvent-based synthesis of rare-earth compounds, particularly low temperature processes in water and nonaqueous liquids."

For more information on the conference and for online registration and abstract submission, visit http://www.icstr.rutgers.edu. Ms. Phyllis Cassell is the conference secretary, and she can be contacted at Dept. of Ceramic and Materials Engineering, Rutgers University, 607 Taylor Road, Piscataway, NJ 08854, USA, Tel: 732-445-5036, Fax: 732-445-6264, e-mail: pcassell@rci.rutgers.edu. Prof. Riman can be contacted at: Tel: 732-445-4946, Fax; 732-445-6262, or e-mail: riman@email.rci.rutgers.edu. ▲

Conference Calendar

Note: Reach as many potential conference attendees as possible! Send us your conference announcement and we will publish it here. ▲

March '02

4th Bi-annual School on the Physics and Chemistry of Actinides
and
32emes Journees des Actinides (32JA)
Ein-Gedi, Israel
March 17-22, 2002
RIC News **XXXVI**, [3] 3 (2001)

June '02

14th International Symposium on Boron, Borides, and Related Compounds (ISBB'02)
St. Petersburg, Russia
June 9-14, 2002
RIC News **XXXVI**, [3] 3 (2001)

July '02

The 23rd Rare Earth Research Conference
Davis, California, USA
July 13-18, 2002
RIC News **XXXV**, [2] 4 (2000)
RIC News **XXXVI**, [4] (2001)

5th International Conference on Solvothermal Reactions
East Brunswick, New Jersey, USA
July 22-26, 2002
* this issue

August '02

Applied Superconductivity Conference (ASC 2002)
Houston, Texas, USA
August 4-9, 2002
RIC News **XXXVI**, [3] 1 (2001)

17th Int. Workshop on Rare-Earth Magnets and their Applications
Newark, Delaware, USA
August 18-22, 2002
RIC News **XXXV**, [4] 3 (2000)
RIC News **XXXVI**, [4] (2001)

July '03

International Conference on Magnetism (ICM'2003)
Rome, Italy
July 27-August 1, 2003
RIC News **XXXVI**, [1] 4 (2001)

August '03

Scandium Symposium
Oslo, Norway
August 17-23, 2003
RIC News **XXXVI**, [4] (2001)

5th International Conference on f-elements (icfe5)
Geneva, Switzerland
August 24–29, 2003
RIC News **XXXVI**, [4] (2001)

*This issue denotes that an article on this conference appears in this issue of the *RIC News.*

Permanent Magnets and Related Devices

Edward P. Furlani's new book, *Permanent Magnet and Electromechanical Devices*, gives an excellent overview to a topic that is of wide-reaching importance to modern everyday life. Permanent magnets and electromechanical devices are found in products that range from audio and video applications, telecommunications equipment, personal computers, printers, copiers, automobiles, appliances, power tools, data storage, and biomedical applications. This book presents much of the theory involved in creating such devices, along with many good examples of practical problems with solutions. The book is published by Academic Press as part of its Series in Electromagnetism.

The book is well thought out and is presented in a logical order. The five chapters are Materials, Review of Maxwell's Equations, Field Analysis, Permanent Magnet Applications, and Electromechanical Devices. The chapter on materials provides an introduction to magnetism in general as well as a guide to materials classification according to magnetic behavior. Specific materials systems, including samarium-cobalt and neodymium-iron-boron, are also discussed. The Maxwell's equations chapter is included just as a brief reminder, and is not meant to be a comprehensive treatment. However, this chapter is present because of the importance of Maxwell's equations to the solution of many of the problems presented later in the text. The Field Analysis is a presentation and review of several different analysis theories and methods, including magnetostatic field theory, current and charge models for magnetic materials, magnetic circuits, boundary-value theory, the method of images, finite element analysis, and the finite difference method. The final chapters present many detailed problems and solutions. Chapter four presents several different permanent magnet applications, in general terms, and solutions to problems in these cases. Chapter five presents problems and solutions in more specific terms, actually showing how to solve the problems for actual devices. Four appendices are also included that cover vector analysis, Green's functions, systems of equations, and units. These appendices are useful for greater insight into the problems solved in the book.

According to the author, the book in intended as a text and reference for researchers, professors, graduate students, and engineers, essentially anyone who works with the research and development of new and conventional permanent magnet and electromechanical devices. The attention to both theory and applications, the detail of the discussions and problems while being as concise as possible, and the wide variety of permanent magnet devices discussed makes this 518-page book a valuable tool. There are many figures and equations throughout that effectively illustrate the key points of the text, making it understandable for those who may have a less-extensive background in magnetic theory. Each chapter concludes with a reference list for further reading and information.

Permanent Magnet and Electromechanical Devices: Materials, Analysis, and Applications, by Edward P. Furlani, is published by Academic Press, A Harcourt Science and Technology Company, 525 B Street, Suite 1900, San Diego, CA 92101-4495, USA, http://www.academicpress.com, ISBN 0-12-269951-3. Edward P. Furlani is with Research Laboratories, Eastman Kodak Company, Rochester, New York. ▲

Nd_2O_3 acts as a decolorizer in high boric oxide glasses and is used as a dopant in laser glasses, monocrystals, and garnets.

Feedback?

See something in the *RIC News* that you'd like to comment on? Have something of interest to the rare earth community? We welcome your feedback and input! Send any letters to the editor, comments on the *RIC News*, or submissions you would like considered for publication to the *RIC News*, 112 Wilhelm Hall, Ames Laboratory, Iowa State University, Ames, Iowa 50011 USA, e-mail: ric@ameslab.gov. We look forward to hearing from you! ▲

Tenth Frank H. Spedding Award

Nominations are now being accepted for the 10th Frank H. Spedding Award, to be conferred at the 23rd Rare Earth Research Conference, 14-18 July 2002 in Davis California. This prestigious award is given in recognition of excellence and achievement in research centered on the science and technology of rare earths. The Award winner will be asked to present a seminar on the highlights of their work at the meeting. Previous award winners incude:

1st W. E. Wallace (U.S.) Rare Earth Intermetallics and Hydrides, Nitrides
2nd Georg Busch (Switz.) Chemistry and Physics of Semiconductors
3rd S. Legvold and W. Koehler (U.S.) Magnetic Properties of Rare Earth Metals
4th A. Mackintosh and H. Bjerrum Moeller (Denmark) Foundations of Rare Earth Magnetism
5th B. R. Judd (U.S.) Rare Earth Spectroscopy
6th Karl A. Gschneidner, Jr. (U.S.) Rare Earth Materials
7th Leroy Eyring (U.S.) Thermodynamics and Structures of Oxides
8th Gregory Choppin (U.S.) Factors in Lanthanide (III) Complexation
9th M. Brian Maple (U.S.) Superconductivity and Magnetism

Nominations must include:

* A two page nomination letter outlining the candidates contribution to rare-earth science and/or technology
* A minimum of 6 supporting letters
* The candidates curriculum vitae

The nomination packets are due no later than 15 March 2002, and are to be sent to L. Soderholm, Chemistry Division, Building 200, Argonne National Laboratory, Argonne IL 60439, USA; Phone: 630 252 4364; Fax: 630 252 9289; e-mail: LS@anl.gov. ▲

La_2O_3 is a dopant for high refractive index in fiber optic glasses and x-ray image intensifying screens.

Rare-Earth Metal Surfaces

The study of rare-earth metal surfaces is the focus of a book by Steve Barrett and Samjeet Dhesi entitled *The Structure of Rare-Earth Metal Surfaces*. The book provides an introduction to rare-earth metals in general and to their surface structures in particular. It is essentially a review of the studies that have been conducted through 1999 on the surfaces of rare-earth metals. It includes the experimental techniques and theoretical calculations employed in these studies, on the atomic and nanoscale surface structures.

The book consists of eight chapters and one appendix. The first chapter provides and excellent overview to the rare-earths. The origin of the term "rare-earth" is discussed, and the history of their discovery and placement in the periodic table is presented. This chapter also includes some basic information on the properties and applications of the rare-earths. The second chapter addresses the basics of surface structures. It presents a fairly detailed treatment of crystallography, with particular attention to surfaces, where there is some variation from the crystal structure of the bulk material. The third chapter introduces the analysis techniques used to study surface structure. Electron and x-ray diffraction, including LEED, RHEED, and surface x-ray diffraction, scanning tunneling microscopy, and photoelectron diffraction are introduced. Chapter 4 covers the growth and preparation of samples. Thin-film and bulk samples and the preparation of their surfaces for measurement are discussed. The next chapter is on rare-earth surface science, and covers geometric structure and electronic structure and the methods used for analysis. This chapter also touches on surface magnetism. Chapter 6 is devoted to quantitative LEED and includes some of the finer points of this technique, and Chapter 7 presents results obtained from quantitative LEED measurements. The final chapter is a brief summary and outlook for the future of rare-earth surface science. The appendix essentially lists all the studies performed on surface structures of the rare-earths in table form.

The purpose of the book, according to the authors, is to serve as an introduction to surface crystallography and also as an introduction to the rare-earth metals, showing areas of study currently being researched. It is aimed at graduate students with an interest in crystallography, but has minimized the rigorous mathematical treatment favored by physicists. The intent is not to be comprehensive, but to offer a review of the topic. Some sections have further reading suggestions, but the reference list is placed at the end of the book and included 737 individual citations, which should give an interested person plenty of follow-up reading material. The list of abbreviations at the beginning of the book is very useful, as many of the acronyms are used throughout the text.

The Structure of Rare-Earth Metal Surfaces, by S. D. Barrett and S. S. Dhesi, is published by Imperial College Press, London, England, and is distributed by World Scientific Publishing Co. Pte. Ltd., River edge, NJ, USA, ISBN 1-86094-165-6. S. D. Barrett is with the University of Liverpool, UK, and S. S. Dhesi is with the European Synchrotron Radiation Facility, France. ▲

Nd_2O_3 is a violet colorant in glass.

Corrosion Protection of Aluminum and Steel

"Use of Rare Earth Metal Salt Solutions for Corrosion Protection of Aluminum Alloys and Mild Steel," by F. Mansfeld, *Russian Journal of Electrochemistry* **26** [10] 1063-1071 (2000), shows how cerium and yttrium salts can be used to reduce corrosion.

The rare earth salts reduce corrosion on the aluminum alloy surface by replacing the copper, thus eliminating cathode sites and filling in surface pores. There is a significant reduction in the pitting of the surfaces treated with rare earth salts when immersed for days in NaCl solutions as compared to other surface treatments. Rare earth metal salt solutions were also used for sealing anodizing layers on aluminum alloys. These materials passed the salt spray test as well as exhibited excellent paint adhesion.

A 2^3 factorial experiment design was developed to find the optimum conditions for cerating treatments of mild steel for use in hot NH_3 - water solutions used in heat pumps. They determined the optimum concentration and treatment time. A dual strategy that combines cerating the steel surfaces and also using a rare earth metal salt in the working solution is expected to further enhance the corrosion protection of the steel.

For more information, contact F. Mansfel, Corrosion and Environmental Effects Laboratory (CEEL), Department of Materials Science and Engineering, University of Southern California, Los Angeles, CA 90089-0241, USA. ▲

CeO_2 oxidizes iron in glass.

Consultant's Corner

To appear in our Consultant's Corner, any individual, company, or group must be involved in rare earth or rare-earth-related consulting activities. Just send us the appropriate information: contact name, company name, mailing address, Tel/Fax number(s), e-mail, web address, and areas of expertise.

We are always updating our consultants information, so if you have submitted your information in the past but have something that has changed, if you are new to rare-earth consulting, or if it has been a while since you have had any of your information published in the *RIC News*, please resubmit your information: Tel: (515) 294-2272, Fax: (515) 294-3709, or e-mail: ric@ameslab.gov.

Spontaneous Materials, 12348 Melrose Circle, Fishers, IN 46038 USA. Tel: 317 596 0858, Fax: 317 577 4106, e-mail: strout@ieee.org, www.spontaneousmaterials.com ▲ Areas of expertise: specialize in solving technical and commercial problems for clients worldwide in the following general categories: rare earths, magnetic materials, technical training and technical writing.

Rare-Earth Magnetic Separators

Rare-earth magnetic separators (REMS) are in use in heavy mineral sand processing plants around the world. In a paper presented at the *International Heavy Minerals Conference* held in Fremantle, WA, last June, B. R. Arvidson showed the benefits of using REMS and how their use could even be expanded further.

Rare-earth magnet separation technology was first used in heavy mineral sands separation in the 1980s, and was widely accepted by the early 1990s. Rare-Earth Roll Magnetic Separators (RERMS) and Rare-Earth Drum Magnetic Separators (REDMS) have replaced cross-belt and disk separators, and are in some cases replacing Induction Roll Magnetic (IRM) separators. Laboratory experiments show higher yields with RERMS, but lab experiments do not always show how the techniques will work in real-world situations. However, the indicators are that the lab results will indeed be reflected on the industrial scale.

Technical features of dry REDMS and wet REDMS are outlined in the paper, as are flowsheets showing the improvements that use of REDMS would make over conventional separation processes. Some of the economic advantages are also outlined. The advantages of the REMS technology include larger capacity per unit, greater separation efficiency that reduces circulating loads, and high operation availability. These advantages also mean costs can be reduced by reducing the size needed for the processing facility.

The paper is called "The Many Uses of Rare-Earth Magnetic Separators for Heavy Mineral Sands Processing," published in *International Heavy Minerals Conference*, Fremantle, WA, 18-19 June 2001, 131-136 (2001). For more information, contact B. R. Arvidson, Outokumpu Technology Inc., Physical Separation Division, 1310-1 Tradeport Drive, Jacksonville, FL 32218, USA, e-mail: bo.arvidson@outokumpu.com. ▲

Er_2O_3 is a pink colorant in glass.

Search of the Month

Ric Database

keywords BIOMAGNETISM

or

Document Number	***Article***
199535720	Cooling of Squids using a Gifford-McMahon cryocooler containing magnetic regenerative material to measure biomagnetism FUJIMOTO;S KAZAMI;K TAKADA;Y YOSHIDA;T OGATA;H KADO;H Cryogenics 35, 143-8 (1995) (ER,NI) 1995 BIOMAGNETISM CRYOCOOLER ER3NI SQUID
199918010	Research frontiers in magnetic materials at soft x-ray KORTRIGHT;JB AWSCHALOM;DD STOHR;J BADER;SD IDZERDA;YU PARKIN;SSP SCHULLER;IK SIEGMANN;H-C J. Magn. Magn. Mater., 207, 7-44 (1999) (Dy,Y) (Gd,Y) (La,Sr)MnO3 (LaMnO3,SrO) (Nd,B,Fe) (Sm,Co) (Sm,Fe,Ti) (Y,Co) 1999 anisotropy-const bibliography biomagnetism domain domain-wall electron-spect mag-film mag-memory mag-ordering mag-prop magnetoresist microscopy molecular-mag NdFeB phase-transiti quantum review SmCo5 SmFe11Ti spin structure synchrotron tunneling x-ray x-ray-scatter x-ray-spect YCo5

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This search above satisfies a request for information on biomagnetism. Many more citations would have been referenced if other terms had been included in the search.

The Database Report, as shown above, is sent when the search results are purchased, includes full reference information: our document number, title, authors, bibliographic reference, and keyword list. The preliminary search report, which is provided when the search is requested as an evaluative tool, includes the keywords used for the search, the title of the article, and the other keywords associated with the reference, for each of the references found.

The cost to receive the full report for this search is US$50.00. The minimum cost for any search is US$50.00, which includes the reference list for up to 25 matches, and any additional matches are available for US$2.00 each. That means that if a search turns up 30 matches, the full report would cost US$60.00. Supporters may receive as many searches as desired for US$300.00 per year for corporate memberships, or US$100.00 for individual memberships. For other support levels available, see "March 2002 Supporters" on page 8.

As an added benefit, supporters receive a 2-page monthly newsletter, the *RIC Insight*, that reports on late-breaking news of rare earths and how these developments may impact the rare earth industry. Corporate members can also have space on our website, providing additional exposure for their company and links to their own webpages.

If you would like us to conduct a search for you, please send your request to: Angela O'Connor, RIC, 112 Wilhelm Hall, Ames Laboratory, Iowa State University, Ames, IA 50011-3020 USA; Tel: 515-294-5405; Fax: 515-294-3709; e-mail: ric@ameslab.gov. If you would like to become a supporter of the RIC, send your name, address, telephone, fax, e-mail address, and your desired level of support to the above address or to LaVonne Treadway, RIC, 116 Wilhelm Hall, Ames Laboratory, Iowa State University, Ames, IA 50011-3020 USA, Tel: 515-294-2272; Fax: 515-294-3709; e-mail: crem_ric@ameslab.gov. ▲

News from Japan

The RIC thanks Kensuke Shimomura for providing the content and translations for this section.

The Nikkei Weekly, November 19, 2001: Researchers at Saga University and Miyazaki University have synthesized rare-earth oxides in nanotube form. The tubes are made from erbium-, ytterbium-, lutetium-, and thulium oxides, and were as cylinders with lengths up to 200 nm and with an inner diameter of 6 nm. Because of the unique properties of rare-earth metals, the new nanotubes are expected to show properties not seen in carbon nanotubes. The researchers now plan to fill the tubes with a variety of elements with the hope of finding new functions for the materials.

The Nikkei Weekly, November 26, 2001: NGK Insulators Ltd. will shift part of its domestic operations that produce ceramic catalyst carriers for automobile exhaust gas purification to China. NGK hopes to increase price competitiveness by the move.

The Japan Times, December 1, 2001: Ford Motor Co. and Toyota Motor Corp. are planning to jointly develop a new gasoline-electric hybrid vehicle that they may jointly produce in North America. They hope to spread out the cost of the gasoline-electric hybrid technology by the combined effort.

Honda Motor Company Press Release, December 13, 2001: The new Civic Hybrid sedan, a 5-passenger vehicle that gets 29.5 km/L, is on sale at Honda Primo dealers across Japan on December 14, 2001.

The Japan Times, December 14, 2001: DaimlerChrysler AG plans to market the first fuel cell powered bus next year. They also have a concept vehicle called the Town & Natrium van, which may have a better chance of being a commercially viable, non-polluting vehicle. The Natrium uses a third generation fuel cell and a novel storage system that uses borax.

The Nikkei Weekly, December 17, 2001: Researchers at Sumitomo Electric Industries Ltd. have developed a technique to make metal particles in the 10 nanometers to 4 microns in diameter at about half the cost of existing methods. The method works on any metal that can be plated. The process involves a solution of metal ions that is mixed with a solution of titanium ions and a special chemical. Metal particles are created when electric current is applied to the solution, and the size of the particles is determined by the length of time the current flows. Sumitomo is calling this their Titan Redox method. The particles are useful in nanotechnology applications.

The Asahi Shimbun-BUSINESS, January 12, 2002: Sanyo Electric Co. and Samsung Electronics Co. are forming an alliance to develop next generation technologies. Sanyo is hoping to trim its research development costs while developing fuel cells, semiconductors, and liquid crystal displays and while also bringing new items to market more quickly.

The Nikkei Weekly, January 14, 2002: A new water treatment system for industrial wastewater and sewage that uses superconducting magnets to remove phosphorous has been developed by Hitachi Ltd. and Obayashi Corp. The new system removes 85% of the phosphorous from water, while taking up only 10% of the space of current systems, and costing 30% less to build and 20% less to run than current systems. The three step process includes adding agglutinating agents and magnetized iron powder to the water, which is then removed using the superconducting coil to create a magnetic field, and then nitrogen is removed from the water by placing it in tanks full of certain aquatic plants.

The Japan Times, January 16, 2002: Fuji Heavy Industries Ltd. is planning to release a hybrid minicar by fiscal 2005. While hybrid cars are already in existence, no hybrid minicars are on the market. A minicar has an engine displacement of 660cc or less.

The Nikkei Sangyo Shimbun, February 1, 2002: Daido Electronics Co., in partnership with Fukoku Co., has developed high-powered Nd-Fe-B flexible magnets. The new NF series® has a magnetic force of 68 kJ/m³. The sheets can be applied to car motors and sensors to make smaller and lighter products. The sheets can also withstand temperatures from 120YC to -30YC. The new product will be delivered primarily to manufacturers of small motors beginning in April.

The Nikkei Weekly, February 4, 2002: Mitsubishi Corp. will establish an investment fund specializing in fuel-cell technology in March. Mitsubishi will team up with Johnson Matthey Plc and a Dutch member of the Royal Dutch/Shell group of Cos. The fund is expected to become the world's largest fund investing in fuel cell and hydrogen-related technologies.

The Nikkan Kogyo Shimbun, February 6, 2002: Santoku Corp. is increasing its production capacity of NiMH alloys in China by 2.5-fold to 500 metric tons per year. The increase was prompted by expected growth in demand for rechargeable nickel hydride batteries for use in mobile phones and PCs as world makers of those products are preparing to move production to China. Santoku will build a new plant to be completed in April 2002. ▲

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To receive the *RIC News* via e-mail, please specify which format you would prefer, and send your e-mail address to RIC, 112 Wilhelm Hall, Ames Lab, Iowa State University, Ames, IA 50011-3020 USA or ric@ameslab.gov. ▲

Newsletter on the Web

A paperless alternative to receiving an electronic form of the *RIC News* via e-mail is to access our website: http://www.ameslab.gov/ric, where current and previous issues of the *RIC News* are available, along with general information about the Rare-earth Information Center and a list of our sponsors. ▲

X-Ray Storage Phosphors

Diagnostic x-rays rely on the sensitivity of the storage medium to show details key to making an accurate diagnosis. Originally, conventional photographic film was used, but since it is not very sensitive to x-rays, high radiation doses were required. The combination of scintillator layers with the photographic film greatly increased the sensitivity of the imaging system, thus reducing the radiation exposure to the patient. X-ray storage phosphors are even better, as they exceed the sensitivity of the scintillator system by at least an order of magnitude. Also, the image is directly digitized and can be easily stored. However, the x-ray storage phosphor system is still inferior due to the scattering effects of the stimulation light during the read-out process. "Physics and Current Understanding of X-Ray Storage Phosphors," by S. Schweizer, Phys. Stat. Sol. (a) **187** [2] 335-393 (2001), presents a brief overview of x-ray phosphors.

The organization of the article leads the reader into the topic. First, experimental fundamentals are covered. Magneto-optical measurement techniques are introduced, which include magnetic circular dichroism of the optical absorption, optical detection of electron paramagnetic resonance (EPR) and electron nuclear double resonance (ENDOR), and cross-relaxation spectroscopy. The introduction to the techniques leads into greater discussion of EPR and ENDOR and a brief mention of magic angle spinning nuclear magnetic resonance.

Second, x-ray storage phosphors in general are addressed. Topics include performance, spatial resolution of the image plates, and the read-out process of the image plates. The next three sections cover specific x-ray storage phosphor materials. $BaFBr:Eu^{2+}$ is so far the best available material for this purpose. When irradiated with x-rays, electron and hole trap centers are created that are stable at room temperature. While the principles of storage and read-out are simple, it is not fully understood how the recombination energy is transferred to the Eu^{2+} for emission. Clarifications are made between stoichiometric and non-stoichiometric compounds, and the effect of doping with Ca^{2+} or Sr^{2+} and also the structure of the material in the vicinity of the Eu^{2+} are discussed. The other materials receiving attention are Alkali halides and elpasolites, and glasses and glass ceramics.

The text is supported by 1 table, 35 equations, 53 figures, and 118 references. Overall this is an interesting topic, with room for more research for greater understanding.

For more information on the subject, S. Schweizer can be contacted at Fachbereich Physik, Universität Paderborn, D-33095 Paderborn, Germany. ▲

Superconductivity and Magnetism in Borocarbides

The interaction of magnetism and superconductivity in rare-earth materials has provided the basis for much research. The interest in this topic was again piqued eight years ago with the discovery of superconducting borocarbides. The research on RNi$_2$B$_2$C materials is reviewed in "Interaction of superconductivity and magnetism in borocarbide superconductors," by K.-H. Müller and V. N. Narozhnyi, *Rep. Prog. Phys.* **64** 943-1008 (2001).

The interaction between superconductivity and magnetism in borocarbides behaves differently than in both classical magnetic superconductors and high-T_c cuprates. In the latter two cases, the superconducting state coexists with antiferromagnetic ordering on the rare earth sublattice, with the magnetic ordering temperature T_N much below the superconducting transition temperature, T_c. In borocarbides, Ni does not carry a magnetic moment (in contrast to Cu in cuprates), and various types of antiferromagnetic structures exist on the rare-earth sublattice and coexist with superconductivity. In the borocarbides, T_c is not always greater than T_N, and while the de Gennes factor correlates well with T_N and T_c for the most part, it does not for all borocarbide compounds, and one big exception in the pseudoquaternary compounds with two rare earths. This results from effects of the electron structure, crystalline electric fields, variations in ionic radii, and nonmagnetic impurities. This article reviews much of the work done on borocarbide superconductors with the aim of clarifying the details of the interaction between the superconductivity and magnetism.

To make their points, the authors follow a logical path through their article. They begin with an introduction to borocarbides, and outline some of the history of the compounds as well as identify some of the features of borocarbide superconductors. They then discuss the crystal structure of the compounds, presenting basic structural and magnetic properties, and mentioning how the multilayer structures in some borocarbides help understand the mechanisms of superconduction and magnetism. However, this article is limited to single-layer compounds. A discussion of non-magnetic YNi_2B_2C and $LuNi_2B_2C$ follows, with the aim of describing the superconducting state in the borocarbides without the added complication of magnetism. This is a fairly detailed treatment, and includes sections on normal-state electronic properties, the upper critical field, vortex lattices, and magnetotransport. The flow of the paper then progresses to magnetic compounds, with individual discussions of 11 different rare-earth borocarbide compounds. This is followed by a brief section on the suppression of superconductivity in the pseudoquaternary $(R,R')Ni_2B_2C$, with the goal of better understanding intermediate states and the mechanisms used in these materials for superconductivity and magnetism.

This paper is well written and easy to follow. The 4 equations, 7 tables, and 41 figures succeed well in clarifying the points made. The points made and conclusions drawn are supported by 346 references. The paper provides an excellent overview to an exciting and interesting topic. For more information, K.-H. Müller can be reached at the Institut für Festkörper-und Werkstofforschung Dresden, POB 270016, D-01171 Dresden, Germany. V. N. Narozhnyi can be contacted at the Institute for High Pressure Physics Russian Acad. Sci., Troitsk, Moscow Reg., 142190, Russia. ▲

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